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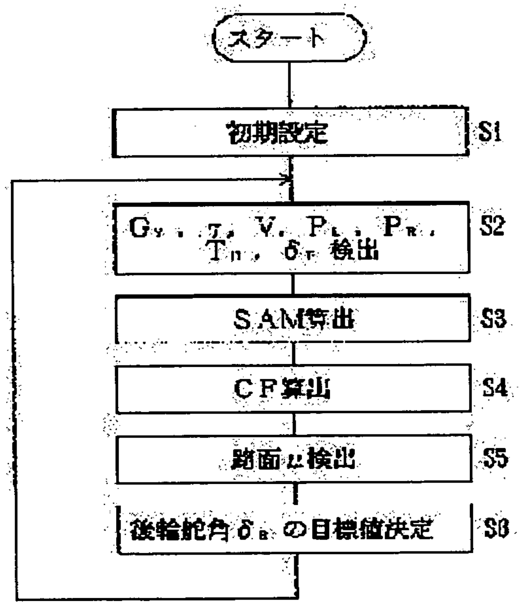
(54) ROAD SURFACE FRICTION COEFFICIENT DETECTION DEVICE

(57)Abstract:
PURPOSE: To enable detecting road surface beforehand of falling in grip limit of wheels based on the relation of wheel receovery moment and cornering force by using a device detecting road surface based on the cornering characteristics of wheels.
CONSTITUTION: There is a fact that the increase slope of recovery moment to cornering force is different for road surface μ fairly prior to the step wheels fall in grip limit. By making use of this fact, the road surface μ is detected. Further in detail, for 4 wheel vehicles with power steering device, the receovery moment SAM around the king pin of front wheels is calculated (S3) based on the left and right pressure PL, PR of the power cylinder and steering torque TH (S2), the cornering force CF of the front wheels is calculated (S4) based on time differentiated value of vehicle body yaw rate and horizontal acceleration CY at the vehicle gravity center, and from the relative relation of the calculated values, the road surface μ is detected.



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CLAIMS

[Claim(s)]

[Claim 1] Road surface coefficient-of-friction detection equipment characterized by providing the following. A resisting-moment detection means to detect the resisting moment which acts on a wheel in the direction which reduces the horizontal slip angle of that. A cornering-force detection means to detect the cornering force which acts on the wheel. A road surface coefficient-of-friction detection means to detect coefficient of friction of the road surface which the aforementioned wheel touches based on the relation between the detection resisting moment by the aforementioned resisting-moment detection means, and the detection cornering force by the aforementioned cornering-force detection means.

[Claim 2] Furthermore, road surface coefficient-of-friction detection equipment according to claim 1 which is what detects road surface coefficient of friction based on the relation of the detection resisting moment and detection cornering force in which the aforementioned road surface coefficient-of-friction detection means received the influence of the hysteresis suppression means, including a hysteresis suppression means to suppress that a hysteresis occurs, between a detection resisting moment and a detection cornering force.

[Claim 3] the aforementioned hysteresis suppression means -- at least one side of a detection resisting moment and a detection cornering force -- an amendment -- the road surface coefficient-of-friction detection equipment according to claim 2 which is a detection value amendment means to suppress generating of the aforementioned hysteresis by things

[Claim 4] Furthermore, between a detection resisting moment and detection cornering forces, A storage means to relate a relation in case a hysteresis does not exist with road surface coefficient of friction, and to memorize it is included. And road surface coefficient-of-friction detection equipment according to claim 2 or 3 which is that to which the aforementioned road surface coefficient-of-friction detection means outputs road surface coefficient of friction corresponding to the relation of the detection resisting moment and detection cornering force which were influenced of the aforementioned hysteresis suppression means according to the content of storage of the storage means.

[Claim 5] Furthermore, road surface coefficient-of-friction detection equipment including a detection precision presumption means to presume the precision of detection by the aforementioned road surface coefficient-of-friction detection means according to claim 1 to 4.

[Claim 6] It can change into what has the general rule which the aforementioned road surface coefficient-of-friction detection means uses in case it detects, and a special thing. When this detection is performed according to a general rule, the detection precision is what presumes whether it may fall below to the set point. the aforementioned detection precision presumption means -- the road surface coefficient-of-friction detection means -- the above -- furthermore -- the case where it is presumed that detection precision may fall by the detection precision presumption means -- the aforementioned road surface coefficient-of-friction detection means -- the above -- the road surface coefficient-of-friction detection equipment containing the detection rule control means to which this detection is made to perform according to a special rule according to claim 5

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the equipment which detects coefficient of friction of a road surface indirectly.
[0002]
[Description of the Prior Art] The technology of detecting indirectly coefficient of friction (henceforth a road surface mu) of a road surface is already proposed. It is the technology of detecting a road surface mu from the vehicles deceleration based on the fact that the size of the vehicles deceleration under antilock control which prevents that a wheel lapses into a lock state for example, at the time of vehicles braking corresponds to a road surface mu. Moreover, if the horizontal slip angle of a wheel becomes to some extent large during vehicles revolution, the cornering force which acts on the wheel will be saturated, and based on the fact (refer to drawing 13) that the value at that time corresponds to a road surface mu, the technology of detecting a road surface mu from the saturation value of a cornering force is also already proposed. An example of this technology is indicated by JP,60-148769,A.
[0003]
[Problem(s) to be Solved by the Invention] However, before each of these Prior arts will be in a state with the vehicles near a critical state, it can detect a road surface mu for the first time and vehicles will be in a critical state closely, it is difficult to detect a road surface mu.
[0004] Invention of a claim 1 makes such a situation a background, and it makes enabling it to detect a road surface mu regardless of whether vehicles are in the state near a critical state as a technical problem. Invention of a claim 2 is further made also considering the improvement in detection precision of a road surface mu as a technical problem. Invention of a claim 3 is made considering offering one embodiment of invention of the claim 2 as a technical problem. Invention of a claim 4 is made considering offering these claims 2 or one embodiment of invention of three as a technical problem. In addition to the technical problem of invention of a claim 1, invention of a claim 5 is made also considering enabling evaluation of the reliability of the detection value of a road surface mu as a technical problem. In addition to the technical problem of invention of a claim 1, invention of a claim 6 is made [also raising the detection precision of a road surface mu using the evaluation result of the reliability by invention of the claim 5, or] as a technical problem.
[0005]
[Means for Solving the Problem] In order to solve each technical problem, invention of a claim 1 About road surface coefficient-of-friction detection equipment, as shown in drawing 1 , it is (a). A resisting-moment detection means 1 to detect the resisting moment which acts on a wheel in the direction which reduces the horizontal slip angle of that, (b) A cornering-force detection means 2 to detect the cornering force which acts on the wheel, (c) Based on the relation between the detection resisting moment by the resisting-moment detection means 1, and the detection cornering force by the cornering-force detection means 2, it considers as composition including a road surface coefficient-of-friction detection means 3 to detect coefficient of friction of the road surface which the aforementioned wheel touches.
[0006] Invention of a claim 2 is considered as the composition in which the aforementioned road surface coefficient-of-friction detection means 3 detects road surface coefficient of friction further based on the relation of the detection resisting moment and detection cornering force which were influenced of the hysteresis suppression means 4 between a detection resisting moment and a detection cornering force, including a hysteresis suppression means 4 to suppress that a hysteresis occurs, as shown in drawing 2 .
[0007] the hysteresis suppression means [in / invention of the claim 2 / as invention of a claim 3 is shown in drawing 3] 4 -- at least one side of a detection resisting moment and a detection cornering force -- an amendment -- it considers as a detection value amendment means 5 to suppress generating of the aforementioned hysteresis by things

[0008] Invention of a claim 4 receives invention of claims 2 or 3, as shown in drawing 4 . Furthermore, between a detection resisting moment and detection cornering forces, A storage means 6 to relate a relation in case a hysteresis does not exist with road surface coefficient of friction, and to memorize it is included. And the aforementioned road surface coefficient-of-friction detection means 3 is considered as the composition which outputs road surface coefficient of friction corresponding to the relation of the detection resisting moment and detection cornering force which were influenced of the aforementioned hysteresis suppression means 4 according to the content of storage of the storage means 6.
[0009] Invention of a claim 5 is considered as the composition which includes further a detection precision presumption means 7 to presume the precision of detection by the aforementioned road surface coefficient-of-friction detection means 3 to a claim 1 or invention of 4, as shown in drawing 5 .
[0010] Invention of a claim 6 receives invention of the claim 5, as shown in drawing 6 . It can change into what has the general rule which the aforementioned road surface coefficient-of-friction detection means 3 uses in case it detects, and a special thing. It is what presumes whether the detection precision may fall below to the set point if the aforementioned detection precision presumption means 7 performs this detection according to a rule with the common road surface coefficient-of-friction detection means 3. Furthermore, when it is presumed that detection precision may fall by the detection precision presumption means 7, it considers as the composition containing the detection rule control means 8 to which this detection is made to perform according to a rule special to the road surface coefficient-of-friction detection means 3.
[0011] In addition, the "resisting moment" in invention of each [these] claim can be made into the moment which acts on the circumference of the king pin of a wheel, or let it be a self-aligning torque.
[0012] Moreover, let the "resisting-moment detection means 1" in invention of each claim be the mode which detects a resisting moment based on the pressure of the power cylinder of that, and the steering torque added to a steering wheel by the operator in the vehicles equipped with for example, power-steering equipment.
[0013] Moreover, the "cornering-force detection means 2" in invention of each claim can be made into the mode which detects a cornering force indirectly based on the time differential value of the yaw rate of the body, and the lateral acceleration in a vehicles center-of-gravity point supposing 2 flexibility model of vehicles, or let it be the mode which detects a cornering force directly for example, using 6 component-of-a-force meter etc.
[0014]
[Function] These people found out that a fixed relation was materialized between the resisting moment and cornering force which act on a wheel, and a road surface mu. when the relation makes the steering angle of a steering wheel increase concretely so that it may express with a graph to drawing 12 , it is a relation which a cornering force increases and which a road surface mu increases [the increase inclination] although it is alike and a companion resisting moment also increases of it being alike and carrying out the increase in a companion Furthermore, if a cornering force becomes to some extent large, even if a cornering force continues increasing, a resisting moment will change towards reduction, and the relation of being so large that a road surface mu being [the value of the resisting moment at that time] large will also be materialized.
[0015] on the other hand, so that [in / the relation of the resisting moment and cornering force of a certain thing / in the inclination for the increase inclination of a cornering force to increase, so that a road surface mu is large in the above-mentioned Prior art, as shown in drawing 13] -- **** -- it is not remarkable and the increase inclination which is a cornering force hardly changes with road surfaces mu to 0 in a field with the wheel slip angle also near near and a cornering force 0
[0016] In short, if the relation between a resisting moment and a cornering force is used A cornering force can detect [rather than] a road surface mu from a small field using the relation between a wheel slip angle and a cornering force. In the road surface coefficient-of-friction detection equipment applied to invention of a claim 1 based on such knowledge Based on the relation between the resisting moment detected by the resisting-moment detection means 1, and the cornering force detected by the cornering-force detection means 2, coefficient of friction of the road surface which the wheel touches by the road surface coefficient-of-friction detection means 3 is detected.
[0017] A resisting moment in case "the road surface coefficient-of-friction detection means 3" takes a value (reference value) with a cornering force here, and a relation with a road surface mu are memorized beforehand. According to the relation, consider as the mode which determines the road surface mu corresponding to a detection resisting moment, or The relation beforehand set up between the resisting moment, the cornering force, and the road surface mu can be beforehand memorized as a function, a table, a map, etc., and it can also consider as the mode which determines the road surface mu corresponding to the both sides of a detection resisting moment and a detection cornering force according to the relation. Moreover, it is good also as a mode which detects the peak value of a detection resisting moment and detects a road surface mu with the value.

[0018] Let further this the "road surface coefficient-of-friction detection means 3" be the mode which detects a road surface mu according to the increase inclination of the detection resisting moment to a detection cornering force. The increase inclination of a detection resisting moment can be detected as a differential value about the detection cornering force of carrying out division process of the augend per regularity minute time of a detection resisting moment by the augend per regularity minute time of a detection cornering force, i.e., a detection resisting moment, or can only be detected as a value which broke the detection resisting moment by the detection cornering force.
[0019] In addition, although some modes illustrated about "the road surface coefficient-of-friction detection means 3" above were modes in case the graph with which the cornering force was taken by the horizontal axis and the resisting moment was taken by the vertical axis is assumed, this the "road surface coefficient-of-friction detection means 3" can also be carried out as a mode in case the graph with which the resisting moment was taken by the horizontal axis and the cornering force was taken by the vertical axis still more conversely is assumed. For example, it can also consider as the mode which detects a road surface mu with the value of the detection cornering force when taking a value (reference value) with a detection resisting moment.
[0020] By research of these people, it discovered that a hysteresis occurred between resisting-moment SAM and a cornering force CF so that it might express with a graph to drawing 14 . That is, it was with the time of returning with the time of an operator cutting a steering wheel deeply, and the values of resisting-moment SAM corresponding to the same value of a cornering force CF differed, and this hysteresis discovered the fact that there was an inclination which becomes so remarkable that the operating speed of a steering wheel is large. Therefore, when detecting a road surface mu immediately from the detection value of these resisting-moments SAM, and the relation between detection values of a cornering force CF, without taking existence of such a hysteresis into consideration, a road surface mu cannot always be detected in a precision high enough.
[0021] Based on such knowledge, a road surface mu is detected based on the relation between both detection values which it is suppressed that a hysteresis occurs by the hysteresis suppression means 4 between the detection resisting moment by the resisting-moment detection means 1 and the detection cornering force by the cornering-force detection means 2, and it makes such by the road surface coefficient-of-friction detection means 3 and by which generating of a hysteresis was suppressed in the road surface coefficient-of-friction detection equipment concerning invention of a claim 2. Therefore, it will not ask in any of a state and an OFF return state a steering wheel cuts deeply with a steady state (namely, **** state), and is, but a road surface mu can be detected in a precision high always enough.
[0022] Carry out this the "hysteresis suppression means 4" in the mode in which road surface mu detection is made to perform only within the time of being in one of the operation states where the steering wheel cut for the road surface coefficient-of-friction detection means 3 deeply with the steady state, and was beforehand set to it among the state and the OFF return state, or it is possible to carry out in the mode in which road surface (namely, time of vehicles being in substantial fixed-speed [with little generating] and steady-turning state of hysteresis -- restricting) mu detection is made to perform only within the time of the operating speed of a steering wheel being below the set point However, in these modes, when a steering wheel will be in a specific operation state, a road surface mu cannot be detected but limit of a stage that a road surface mu is detectable is severe.
[0023] Then, in the road surface coefficient-of-friction detection equipment concerning invention of a claim 3, the detection value amendment means 5 is adopted as one embodiment of the hysteresis suppression means 4 in invention of a claim 2. the detection value amendment means 5 -- at least one side of a detection resisting moment and a detection cornering force -- an amendment -- it suppresses that a hysteresis occurs between both detection values by things, and it becomes possible to detect a road surface mu with a sufficient precision regardless of the situation of the operation state of a steering wheel in this case
[0024] Usually let this the "detection value amendment means 5" be an amendment mode for the purpose of a relation in case a hysteresis does not exist in the relation between a detection resisting moment and a detection cornering force. In this case, it can also consider as the relation at the time of assuming that it considers as the relation at the time of assuming that a steering wheel always cuts deeply, for example although it considers as the relation obtained as a result of the "relation's in case a hysteresis does not exist" usually acquiring a resisting moment and a cornering force by an experiment, numerical analysis, etc. on each road surface mu of every in the state of the fixed speed of vehicles, and steady turning, respectively, and it is in a state, or is always in an OFF return state conversely. therefore, it not only considers as the mode which a steering wheel cuts "the detection value amendment means 5" deeply, and amends a detection value also in an OFF return state also in a state, but for example, to the value at the time of assuming that it amends, the detection value in an OFF return state is cut deeply, and it is in a state only case [in an OFF return state], consider as an amendment mode or On the contrary, only case [in an infeed state], it can amend and cut deeply and let the detection value in a state be an amendment mode at the value at the time of assuming that it is in an OFF return state.

[0025] Then, it sets to the road surface coefficient-of-friction detection equipment concerning invention of a claim 4. By the storage means 6, a relation in case the hysteresis between a detection resisting moment and a detection cornering force does not exist relates with a road surface mu, and it memorizes. by the road surface coefficient-of-friction detection means 3 According to the memorized relation, the road surface mu corresponding to the relation of the detection resisting moment and detection cornering force which were influenced of the hysteresis suppression means 4 is outputted.
[0026] The road surface coefficient-of-friction detection means 3 cannot always detect a road surface mu with a sufficient precision regardless of situations, such as an operation state of a steering wheel, and a movement state of vehicles. Therefore, it is significant if it can evaluate while detecting the precision of the detection value of the road surface mu by the road surface coefficient-of-friction detection means 3, i.e., reliability. The evaluation result about the reliability of the detection value of a road surface mu is because it can use for improvement in the detection precision of for example, the road surface mu.
[0027] Then, in the road surface coefficient-of-friction detection equipment concerning invention of a claim 5, the precision of detection by the aforementioned road surface coefficient-of-friction detection means 3 is presumed by the detection precision presumption means 7. This detection precision presumption means 7 can make operating speed of a steering wheel etc. an input signal, and can carry it out in the mode which presumes the detection precision of a road surface mu based on it.
[0028] Moreover, it sets to the road surface coefficient-of-friction detection equipment concerning invention of a claim 6. The rule which the road surface coefficient-of-friction detection means 3 uses in case it detects a road surface mu is made into what can be changed into a general thing and a special thing. by the detection precision presumption means 7 If the road surface coefficient-of-friction detection means 3 performs this road surface mu detection according to a general rule, it will be presumed whether the detection precision may fall below to the set point. Furthermore, when it is presumed that detection precision may fall by the detection precision presumption means 7, the road surface coefficient-of-friction detection means 3 is made to detect this road surface mu according to a special rule by the detection rule control means 8. The rule used this time is changed into the rule predicted that detection precision improves from the case where this road surface mu is detected according to a general rule.
[0029]
[Effect of the Invention] Before vehicles will be in a critical state closely since a road surface mu is detected from the relation between a resisting moment and a cornering force according to invention of each claim so that clearly from the above explanation, the effect that a road surface mu can be detected is acquired.
[0030] Moreover, the feature of being hard to be influenced of the grounding load of a wheel, a tire pressure, a tire property (for example, it changing with makers), etc., and the effect that a road surface mu can be detected with a sufficient precision, without being influenced [most] of the grounding load of a wheel etc. according to invention of each claim a certain sake are acquired by the relation between a resisting moment and a cornering force.
[0031] Since the hysteresis between a detection resisting moment and a detection cornering force is suppressed and a road surface mu is especially detected according to invention of claims 2, 3, or 4, the effect that the reliability of the detection value improves is acquired.
[0032] Moreover, according to invention of a claim 5, the effect that the reliability of the detection value of a road surface mu can be evaluated is acquired especially.
[0033] Moreover, since the detection rule of a road surface mu is especially changed proper in a relation with the detection precision of a road surface mu according to invention of a claim 6, the effect that the reliability of the detection value improves further is acquired.
[0034]
[Example] Hereafter, the road surface coefficient-of-friction detection equipment which is some examples of this invention is explained in detail based on a drawing.
[0035] First, the vehicles control unit containing the road surface coefficient-of-friction detection equipment which is one example of invention of a claim 1 is explained.
[0036] This vehicles control unit is formed in the four-flower vehicles equipped with the right-and-left front wheel 10 which is a steering wheel, and the right-and-left rear wheel 12 which is a drive-pulley ring, as shown in drawing 7 . Steering torque TH added to the right-and-left front wheel 10 by the operator at the steering wheel 20 It is assisted by the power-steering equipment which has a power cylinder 22, is transmitted, and, thereby, is front-wheel rudder angle deltaF. According to the steering angle theta of a steering wheel 20, it is changed mechanically. On the other hand, the right-and-left rear wheel 12 is the rear wheel rudder angle deltaR. It is electrically changed by the rear wheel steering actuator 26.
[0037] This vehicles control unit is constituted by having the vehicles control computer 28, connecting various sensors

to the input side of that, and connecting the rear wheel steering actuator 26 to the output side of that, as shown in drawing 8 . The vehicles control computer 28 is rear wheel rudder angle deltaR, when various routines including the vehicles control routine expressed with the flow chart to drawing 9 in ROM of that are memorized beforehand and CPU performs it. It is controlled.

[0038] Hereafter, although the content of the vehicles control routine is explained, it explains roughly first.

[0039] It sets to this vehicles control routine, and is rear wheel rudder angle deltaR. Desired value is determined as follows. That is, it is determined using the formula which gamma [deltaR =KF, deltaF+KB, and] Comes to be based on the yaw rate gamma, the vehicle speed V, and the road surface mu of front-wheel rudder angle deltaF and the body.

[0040] It is determined that are always negative or 0, and the absolute value becomes small, so that the vehicle speed V is large, and an absolute value will become small, so that a road surface mu is large so that "KF" may be gain which is the function of the vehicle speed V and a road surface mu and a graph may express by drawing 10 and drawing 11 here. That is, it is front-wheel rudder angle deltaF, so that a road surface mu is so large that the vehicle speed is large. Receiving rear wheel rudder angle deltaR Amount of responses, i.e., rear wheel rudder angle, deltaR What acts on the sense which is a rotation by the side of an antiphase, and raises swinging nature becomes small, and is determined that rolling-stock-run stability will improve.

[0041] Moreover, although "KB" is the gain which is the function of the vehicle speed V and a road surface mu, it is determined that are always set to positive or 0, and the absolute value becomes large, so that the vehicle speed V is large, and an absolute value will become small, so that a road surface mu is large so that it may express with a graph to these views. Namely, rear wheel rudder angle deltaR to the yaw rate gamma, so that a road surface mu is so small that the vehicle speed is large Amount of responses, i.e., rear wheel rudder angle, deltaR What acts on the sense which is a rotation by the side of an inphase, and suppresses generating of the yaw rate gamma becomes large, and is determined that rolling-stock-run stability will improve.

[0042] Rear wheel rudder angle deltaR is the front-wheel rudder angle sensor 30 (refer to drawing 8 .). Front-wheel rudder angle deltaF among physical quantity required to determine desired value other sensors -- being the same -- although the yaw rate gamma is detected by the yaw rate sensor 32 and the vehicle speed V is detected by the vehicle speed sensor 34, respectively, a road surface mu is detected as follows

[0043] First, steering torque TH ****** PL and PR of a power cylinder 22 It is based and resisting-moment SAM which acts on the right-and-left front wheel 10 at the circumference of the king pin of that is detected. Namely,
SAM=N-TH+k- (PR-PL)
Resisting-moment SAM is detected using the becoming formula. However, N: Steering gear ratio (fixed value)
k: The product of the pressure-receiving area of a power cylinder 22, and steering-knuckle-arm length (fixed value)
PR : -- fluid pressure PL of the right ventricle of a power cylinder 22 : it is the fluid pressure of the left room of a power cylinder 22 -- steering torque TH the steering torque sensor 36 -- cylinder right room pressure PR a pressure sensor 38 -- cylinder left room pressure PL It is detected by the pressure sensor 40, respectively.

[0044] That is, in this example, resisting-moment SAM of the circumference of the king pin of the right-and-left front wheel 10 is one mode of the "resisting moment" in invention of a claim 1.

[0045] Next, lateral acceleration GY in yaw rate differential gamma' and the vehicles center-of-gravity point which are the time differential value of the yaw rate gamma of the body It is based and a cornering force CF is detected. namely, 2 flexibility model of vehicles -- assuming -- CF=(b-m-GY+ I-gamma ')/L -- a cornering force CF is detected using a formula However, b: Distance between center-of-gravity-rear wheel axles (fixed value)
m: Vehicles mass (fixed value)
I: Yaw moment of inertia of vehicles (fixed value)
L: Wheel base (fixed value)
In addition, lateral acceleration GY By the lateral acceleration sensor 42, the yaw rate gamma is detected by the aforementioned yaw rate sensor 32, respectively.

[0046] And the size of a road surface mu is determined that a vehicles control unit will become so large that the value of the present resisting-moment SAM is specifically large when the present cornering force CF is a reference value although a road surface mu is detected based on the relation between these resisting-moments SAM and a cornering force CF. 1000 [N] can be chosen as this reference value. Whether the grip capacity of a wheel reaches a limitation, and before [since it is this side,] it becomes, and vehicles become a revolution limitation closely according to this vehicles control unit, a road surface mu can be detected by the case where a cornering force CF is 1000 [N] so that clearly from drawing 12 .

[0047] In the above, although the contents of a vehicles control routine were explained roughly, based on drawing 7 , it explains concretely below.

[0048] First, the step S1 (it only expresses with S1 hereafter.) Suppose that it is the same about other steps. It sets, and

initial setting defined beforehand is performed, then it sets to S2, and they are lateral acceleration GY, the yaw rate gamma, the vehicle speed V, the cylinder left room pressure PL, the cylinder right room pressure PR, and the steering torque TH by various sensors. And front-wheel rudder angle deltaF It is detected, respectively and RAM memorizes.

[0049] The cylinder left room pressure PL and cylinder right room pressure PR which were detected as mentioned above in S3 after that And steering torque TH It is based, resisting-moment SAM of a front wheel 10 is computed, and this is also memorized by RAM. Then, in S4, as mentioned above, based on lateral acceleration GY, the yaw rate gamma, and the vehicle speed V, the cornering force CF of a front wheel 10 is computed, and this is also memorized by RAM.

[0050] In S5, a road surface mu is detected from the relation between these resisting-moments SAM and a cornering force CF after that. Although this detection of a road surface mu will specifically be omitted if it is judged whether the present cornering force CF is a reference value and it is not a reference value, if it is a reference value, a road surface mu will be detected so that it may become so large that it is large according to the present resisting-moment SAM. The contents of RAM are saved until the detected road surface mu is memorized by RAM and the new road surface mu is detected by the execution after the next time of this step. In addition, 1.0 is memorized by RAM as initial value of a road surface mu. It is because it is thought on the other hand from the beginning in a vehicles run of each time supposing the case where the detection value of a road surface mu is required that a road surface is generally a quantity mu way. However, let it be the adjustable value in which a setup according to operation of an operator is possible it not only considers initial value of a road surface mu as a fixed value, but.

[0051] Then, in S6, the newest road surface mu is read from RAM, it is based on the road surface mu and the present vehicle speed V, and they are the aforementioned gain KF and KB. this time value is determined. Specifically, they are a road surface mu, the vehicle speed V, and Gain KF. When the relation (drawing 10 and drawing 11) between a relation, and a road surface mu, the vehicle speed V and Gain KB is beforehand memorized by ROM and uses these relations, they are Gain KF and KB. this time value is determined. furthermore, this step -- setting -- above -- these gain KF and KB this time value and the present front-wheel rudder angle deltaF and the yaw rate gamma -- being based -- rear wheel rudder angle deltaR Desired value is determined, and the rear wheel steering actuator 26 is controlled so that it is realized. It returns to S2 after that.

[0052] Thus, in this example, since a road surface mu is detected from the relation between resisting-moment SAM and a cornering force CF and the reference value of a cornering force CF is set as the value near 0 as much as possible, whether a front wheel's 10 lapsing into a grip limitation and the effect of becoming and becoming detectable [a road surface mu] in this side are acquired.

[0053] Furthermore, in this example, the effect of above-mentioned early detection of a road surface mu is accompanied, and it is rear wheel rudder angle deltaR. The effect of making the control characteristic correspond to change of a road surface mu promptly is acquired.

[0054] It sets to this example so that clearly from the above explanation. It cooperates with the portion into which drawing 9 of the vehicles control computer 28 attains to S2, and the steering torque sensor 36 and pressure sensors 38 and 40 perform 3. Constitute one mode of the "resisting-moment detection means 1" in invention of a claim 1, and it cooperates with the portion into which this drawing of the vehicles control computer 28 attains to S2, and the lateral acceleration sensor 42 and the yaw rate sensor 32 perform 4. One mode of the "cornering-force detection means 2" in invention of a claim 1 is constituted, and the portion which performs S5 [of the vehicles control computer 28] of this drawing constitutes one mode of the "road surface coefficient-of-friction detection means 3" in invention of a claim 1.

[0055] In addition, although it does not ask whether vehicles are in a drive state, it is in a braking state in this example, or it is in the fixed-speed run state which are not those any, either but a road surface mu is detected from the relation between a cornering force CF and resisting-moment SAM, in order to raise the detection precision of a road surface mu, it is desirable that it is made to detect a road surface mu only within the time of vehicles being in a fixed-speed run state.

[0056] Moreover, although this example was an example at the time of applying this invention to the road surface coefficient-of-friction detection equipment in the vehicles control unit which controls the behavior of vehicles by rear wheel steering, it is natural. [of invention of a claim 1 being applicable to the road surface coefficient-of-friction detection equipment in vehicles control units, such as an antilock control unit, a traction control unit, and a drive, a braking-force-distribution control unit,]

[0057] Next, the vehicles control unit containing the road surface coefficient-of-friction detection equipment which is one example common to invention of claims 1-6 is explained. In addition, since there are many portions which are common in the above-mentioned example, drawing 9 reaches S3 and the content of execution of 5 differs only from the content of storage of ROM relevant to them, this example explains only the different portion to a detail.

[0058] These people discovered the following facts, as a result of inquiring further about the relation between resisting-

moment SAM and a cornering force CF. That is, a hysteresis exists between resisting-moment SAM and a cornering force CF, it is with under the infeed of the steering wheel 20 by the operator, and OFF return, and resisting-moment SAM corresponding to the same value of a cornering force CF does not become the same value so that it may express with a graph to drawing 14 . And this hysteresis becomes so remarkable that the speed to which an operator does rotation operation of the steering wheel 20, i.e., rudder angle speed, is quick. Therefore, when detecting a road surface mu immediately from the detection value of resisting-moment SAM, and the relation between detection values of a cornering force CF, without taking existence of such a hysteresis into consideration, a road surface mu may be unable to be detected correctly enough. It is because the relation of being large is not always materialized and may be reversed rather than the value of detection resisting-moment SAM corresponding to the same detection cornering force CF can set on a low mu way on a quantity mu way so that clearly from the graph of this drawing.

[0059] Make such a situation into a background and it is made for a hysteresis not to generate these people between detection resisting-moment SAM and the detection cornering force CF. If it is made for the relation of being large to always be materialized rather than the value of detection resisting-moment SAM corresponding to the same detection cornering force CF can set on a low mu way on a quantity mu way One has noticed a road surface mu being always detectable with a sufficient precision, and amendment technology was proposed at least for one side of these detection value as an example of the technology which suppresses the hysteresis.

[0060] And these people adopted resisting-moment amendment technology as an example of the detection value amendment technology. Namely, detection resisting-moment SAM (hereafter, in order to distinguish from the below-mentioned amendment resisting-moment SAM) suppose that it expresses with SAM0 and amendment resisting-moment SAM is expressed with SAM1 on the other hand It is small in the infeed of a steering wheel 20, and enlarges during OFF return. Consequently, ** which is [OFF] it under return that it is among an infeed is not asked, but if the detection cornering force CF is the same as long as a road surface mu is the same, surely same amendment resisting-moment SAM1 will be obtained.

[0061] Let the value of amendment resisting-moment SAM1 be a value according to the relation obtained as a result of acquiring resisting-moment SAM and a cornering force CF on each road surface mu of every in the state of the fixed speed (under the specific vehicle speed) of vehicles, and steady turning, respectively in this example. This relation is an example of a relation in case the hysteresis between amendment resisting-moment SAM1 and the detection cornering force CF does not exist, and the following formula (henceforth a resisting-moment description formula at the time of a stationary) can describe the graph showing this relation.

[0062]

SAM* =mum and CF/alpha (1 (beta-CF/mu) - 2n)

However, SAM* : Resisting moment in fixed speed and a steady-turning state (henceforth a resisting moment at the time of a stationary)

alpha: Constant (for example, 360 [N/kgm])

beta: Constant (for example, 0.000093 [N-1])

m: Constant (for example, 0.5)

n: Constant (for example, 2)

[0063] And in this example, the following are adopted as the concrete technique of the above-mentioned resisting-moment amendment technology. Namely, front-wheel rudder angle deltaF The amendment technique is adopted in detection resisting-moment SAM0 by using the following formula (henceforth an amendment resisting-moment calculation formula) in consideration of the fact that the grade of the above-mentioned hysteresis also increases along with the increase in an absolute value (it expresses with |theta| hereafter), the fact that resisting-moment SAM is large, so that the vehicle speed V is slow, etc.

[0064]

SAM1=SAM0/K-delta 1-delta2-delta3, however K: Correction-factor K=(1+exp (- V/xi))/nuV : Vehicle speed [km/h]

xi : constant (for example, 15 [km/h])

nu : constant (for example, 1.1)

[0065] delta 1: 1st correction value delta1=gammatanh(theta'/(V-delta-mu)) - (1 (beta-CF/mu) - 2n)

theta': Rudder angle speed [rad/sec]

CF: Cornering force [N]

mu : last detection value gamma of road surface coefficient of friction : Constant (for example, 0.3 [kgm])

delta : constant (for example, 0.01 [rad -h/km/sec])

beta : constant (for example, 0.000093 [N-1])

n : constant (for example, 2)

[0066] delta 2: 2nd correction value delta2=epsilontanh (theta'/zeta)

epsilon : constant (for example, 0.7 [kgm])
zeta : constant (for example, 1 [rad/sec])
[0067] delta 3: 3rd correction value delta3=kappatanh (|theta|-theta'/lambda)
kappa : constant (for example, 0.5 [kgm])
lambda : constant (for example, 1 [rad2/sec])
[0068] If this resisting-moment amendment technology is carried out to the relation of the detection resisting-moment SAM0 and the detection cornering force CF which are detected, respectively about low mu ways, such as a hardened snow way, and quantity mu ways, such as a dry asphalt way, and are expressed with the graph to drawing 15 , a hysteresis will not exist between amendment resisting-moment SAM1 and the detection cornering force CF so that it may express with a graph to drawing 16 . The graph of this drawing 16 is a graph obtained when amendment of detection resisting-moment SAM0 is performed ideally, and is resisting-moment SAM* after all at the time of the aforementioned stationary. It is the graph which shows a relation with a cornering force CF about a quantity mu way and a low mu way, respectively.
[0069] In this example, execution of the SAM calculation routine as which this resisting-moment amendment technology is expressed in the flow chart to drawing 17 carries out. In addition, this routine shows the detail of the step which is equivalent to S3 of drawing 9 in this example.
[0070] First, detection resisting-moment SAM0 is computed similarly, next it sets [in / the aforementioned example / on S11 and] to S12, and is front-wheel rudder angle deltaF. Rudder angle speed theta' is computed by lengthening a value last time from this time value. Then, in S13, a correction factor K is computed using the aforementioned formula, and each correction value delta 1, delta 2, and delta 3 is further computed using each aforementioned formula in S14-16, respectively. Then, in S17, amendment resisting-moment SAM1 is computed by substituting the computed correction factor K and each correction value delta 1-delta 3 for the aforementioned amendment resisting-moment calculation formula. One execution of this routine is completed above.
[0071] However, even if it carries out this resisting-moment amendment technology, the precision of the amendment is not always high. Therefore, detection precision may fall in having not asked the situation of the precision of amendment, but having always trusted the value of amendment resisting-moment SAM1, and having detected the road surface mu.
[0072] The following formula (henceforth a detection precision description formula) can describe detection precision deltamu of a road surface mu.
deltamu= (delta mu/delta SAM), deltaSAM=(deltaSAM/deltamu)-1, deltaSAM**(**SAM*/**mu)-1, and deltaSAM
[0073] "deltaSAM" is the amendment error of detection resisting-moment SAM0, and can describe this amendment error deltaSAM by the following formula (henceforth an amendment error description formula) here.
deltaSAM=C+D|theta'|, however C : Constant (for example, 0.7 [kgfm])
D : constant (for example, 1.5 [kgfm-sec/rad])
theta': Rudder angle speed [rad/sec]
[0074] And in this example, reliability S (0<=S<=1) is introduced as a concept which evaluates the grade of the reliability of the detection value of a road surface mu. This reliability S is defined by the following formula (henceforth a reliability definition formula).
S=A/delta mu-B, however A: Constant (for example, 0.125)
B: Constant (for example, 0.25)
[0075] Moreover, in this example, the both sides of the general rule as a rule of detecting a road surface mu from amendment resisting-moment SAM1 in case the detection cornering force CF is in agreement with a reference value, and a special rule are prepared, and it is supposed alternatively that it is usable. This estimate mui of the road surface mu for which it asked here from amendment resisting-moment SAM1 with "the general rule" Past final-value mu* It is this final-value mu* i of a road surface mu by using and carrying out index smoothing (an example of data smoothing). It is the rule to search for. on the other hand, with "a special rule" this estimate mui of a road surface mu without it uses -- final-value mu* i-1 of last time This final-value mu* i as it is ** -- it is the rule to carry out And a rule general to a usual state is followed in this example, and it is this final-value mu* i of a road surface mu. Although detected, if reliability S detects a road surface mu according to a general rule in being fully close to 0, it will be judged that detection precision may fall, and it replaces with the general rule, and a road surface mu is detected according to a special rule.
[0076] Detection of the road surface mu explained above is performed by the road surface mu detection routine expressed with the flow chart to drawing 18 . In addition, this routine shows the detail of the step which is equivalent to S5 of drawing 9 in this example.
[0077] First, this estimate mui of amendment resisting-moment SAM1 and the detection cornering force CF which

were already computed in S31 to the road surface mu It is determined.
[0078] The relation of the resisting-moment SAM and the road surface mu which are expressed with ROM of a computer to drawing 19 in the graph is memorized beforehand. That is, resisting-moment SAM in case the detection cornering force CF is in agreement with a reference value relates with each of two or more road surfaces mu, and is memorized. the value of two or more resisting-moment SAM memorized -- for example, the time of two or more stationaries computed in a resisting-moment description formula at the time of the aforementioned stationary when each of two or more central value (8 for example, 0.2, 0.4, 0.6, 0. 1.0) is substituted for "CF" by the reference value of the detection cornering force CF, and "mu" -- resisting-moment SAM* ** -- it is carried out
[0079] Namely, it is resisting-moment SAM* at the time of a stationary in case the detection cornering force CF of the vehicles control computer 28 is in agreement with a reference value in this example. The portion which relates with each road surface mu and is memorized constitutes one mode of the storage means 6 in each invention of claims 4-6.
[0080] Estimate mui of this time [value / of the road surface mu corresponding to amendment resisting-moment SAM1 according to the above-mentioned relation] when it is judged whether this time value of the detection cornering force CF is mostly in agreement with a reference value and it is in agreement first concretely in these S31 It is determined. On the other hand, when this time value of the detection cornering force CF is not in agreement with a reference value, it is final-value (it mentions later) mu* i of the last time of a road surface mu. Estimate mui of this time of a road surface mu as it is It is determined. Although the above-mentioned relation cannot be used unless the detection cornering force CF is in agreement with a reference value, it is based on the fact that it is few that a road surface mu changes suddenly in connection with a rolling stock run, and it is always estimate mui. It is determined.
[0081] In addition, it sets to this example and is estimate mui of a road surface mu. Although computed as a discrete value For example, it is resisting-moment SAM* at the time of two or more stationaries from which the road surface mu which each generates differs mutually. It is estimate mui of a road surface mu by carrying out linear interpolation. Make it determined as a continuation value, or For example, it is resisting-moment SAM* at the time of **** shown in drawing 20 in a graph, and a stationary. The relation beforehand set up between the cornering force CF and the road surface mu is beforehand memorized to ROM, the relation is followed, and it is estimate mui of a road surface mu. It can be determined as a continuation value.
[0082] In addition, in the graph of drawing 20 , the properties of a graph differ [resisting-moment SAM] between the other fields in the field fully near 0. Since control based on the detection value of a road surface mu may be performed even when vehicles are in a rectilinear-propagation state, in the state of vehicles rectilinear propagation, the standard road surface mu is made to be outputted in vehicles control of antilock control etc., although this cannot detect a road surface mu theoretically with the above-mentioned road surface mu detection technology in the state of the vehicles rectilinear propagation whose resisting-moment SAM is 0 virtually supposing such a case.
[0083] Next, in S32, when amendment error deltaSAM of detection resisting-moment SAM0 uses the aforementioned amendment error description formula, it is presumed. Then, in S33, the resisting-moment change inclination G (=|**SAM*/**mu|) is computed.
[0084] This resisting-moment change inclination G is resisting-moment SAM* as mentioned above at the time of a stationary. Are the value differentiated about the road surface mu, and it sets to this example. The formula which carried out the partial differential of the resisting-moment description formula about the road surface mu at the time of the aforementioned stationary (It is hereafter called a partial-differential formula) is beforehand memorized by ROM, and it is final-value mu* i-1 of the reference value of the detection cornering force CF, and the last time of a road surface mu to this partial-differential formula. this time value of the resisting-moment change inclination G is computed by being substituted.
[0085] Furthermore, in S34, detection error deltamu of a road surface mu is presumed as a product with amendment error deltaSAM by which presumption was carried out [aforementioned] with the inverse number of the resisting-moment change inclination G by which calculation was carried out [above-mentioned]. Then, in S35, the reliability S of this detection value (namely, this final-value mu* i) of a road surface mu is computed by substituting presumed detection error deltamu for the aforementioned reliability definition formula. However, when it becomes larger than 0 and 1 when the value of the formula becomes smaller than 0, as a result of substituting detection error deltamu for a reliability definition formula, it is decided compulsorily, respectively that it will be 1. Or more 0 1 or less and a bird clapper are surely guaranteed for the value of reliability S.
[0086] Then, in S36, it is judged whether this time value of the computed reliability S is fully close to 0. This estimate mui It uses, and a general rule is followed and it is this final-value mu* i. Calculation judges whether the detection precision of a road surface mu may fall. If reliability S assumes this time that there is not enough near in 0, the judgment of S36 will serve as NO and the filter constant R used by the formula of the filter of the below-mentioned index smooth type will be computed by using following formula R=S-delta T/Time in S37.

[0087] "deltaT" is the execution period of this routine, i.e., the detection period of a road surface mu, (for example, 0.1 [sec]), and "Time" expresses the degree of smoothing of a filter with time here (for example, 1.0 [sec]), and all are the constants of fixation. Then, it is this estimate mui-1 of a road surface mu by using formula mu* i =(1-R) mu* i-1+Rmui-1 of the filter of the following index smooth type in S38. Last final-value mu* i Smoothing is carried out and it is this final-value mu* i. It is computed. One execution of this routine is completed above.

[0088] On the other hand, if reliability S assumes that it is fully close to 0, the judgment of S36 serves as YES, will reach S37, will replace with 38, S39 will be performed, and it will set to this step this time. Final-value mu* i-1 of the last time of a road surface mu This final-value mu* i as it is It is carried out and the fall of the detection precision by this using a general rule is suppressed.

[0089] That is, in this example, it is equivalent to the thing in invention of a claim 6 presumed "The detection precision may fall below to the set point if a road surface coefficient-of-friction detection means performs this detection according to a general rule" to judge that the value of reliability S is fully close to 0.

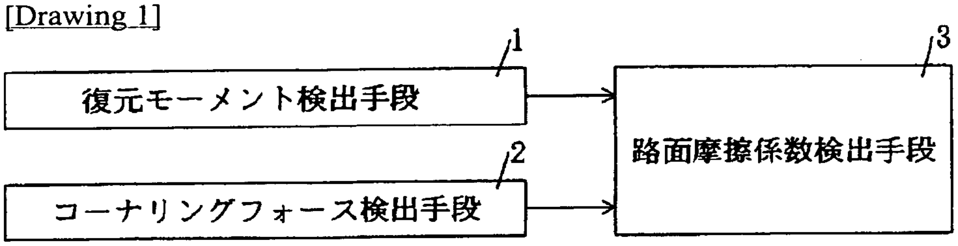
[0090] It sets to this example so that clearly from the above explanation. It cooperates with the portion into which the steering torque sensor 36 and pressure sensors 38 and 40 perform S2 of the thing except S12-17, and drawing 9 among two or more steps of drawing 17 of the vehicles control computer 28. Constitute one mode of the "resisting-moment detection means 1" in each invention of claims 1-6, and it cooperates with the portion into which drawing 9 of the vehicles control computer 28 attains to S2, and the lateral acceleration sensor 42 and the yaw rate sensor 32 perform 4. One mode of the "cornering-force detection means 2" in each invention of claims 1-6 is constituted. The portion which performs the thing except S32-36 among two or more steps of drawing 18 of the vehicles control computer 28 constitutes one mode of the "road surface coefficient-of-friction detection means 3" in invention of a claim 1. Furthermore, the portion which performs S12-17 [of the vehicles control computer 28] of drawing 17 One mode of the detection value amendment means 5 as a hysteresis suppression means 4 in each invention of claims 2-6 is constituted. The portion which memorizes the relation of drawing 19 of the vehicles control computer 28 constitutes one mode of the storage means 6 in each invention of claims 4-6. The portion which performs S32-35 [of the vehicles control computer 28] of drawing 18 constitutes one mode of the detection precision presumption means 7 in each invention of claims 5 and 6. The portion which performs S36 [of the vehicles control computer 28] of drawing 18 constitutes one mode of the detection rule control means 8 in invention of a claim 6.

[0091] As mentioned above, although some examples of this invention were explained in detail based on the drawing, this invention can be carried out in the mode which gave various change and improvement based on this contractor's knowledge, without deviating from the claim other than these.

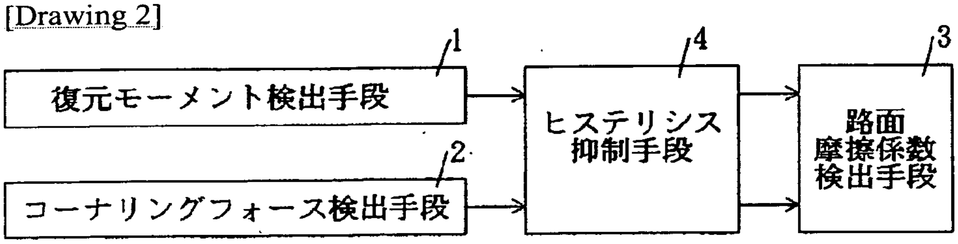
[Translation done.]

DRAWINGS

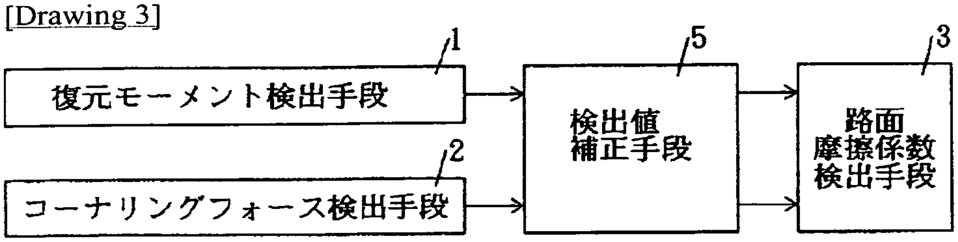
[Drawing 1]



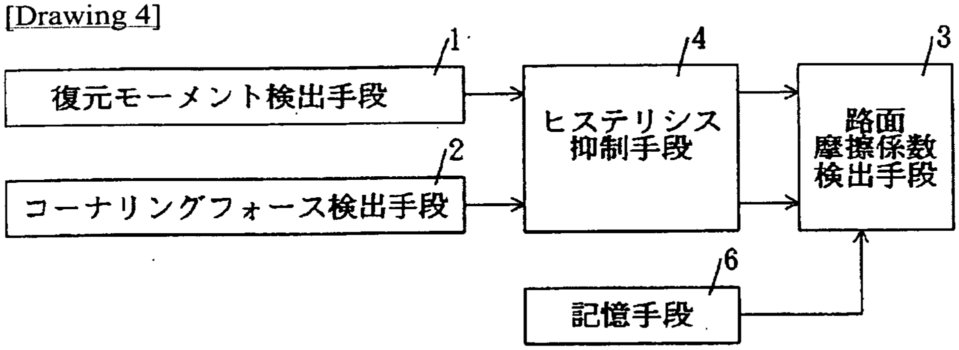
[Drawing 2]



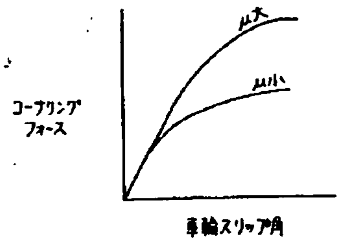
[Drawing 3]



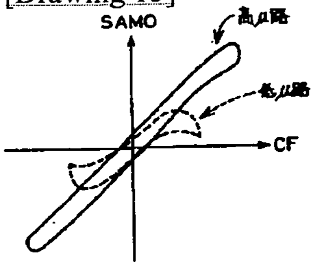
[Drawing 4]



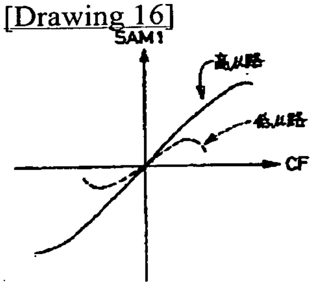
[Drawing 13]



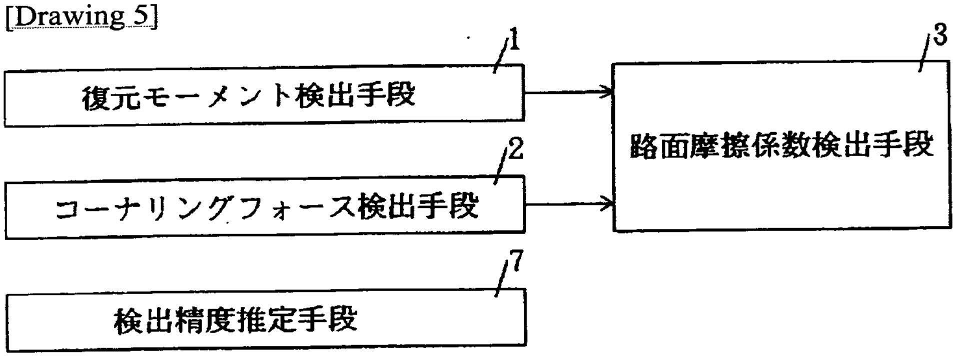
[Drawing 15]



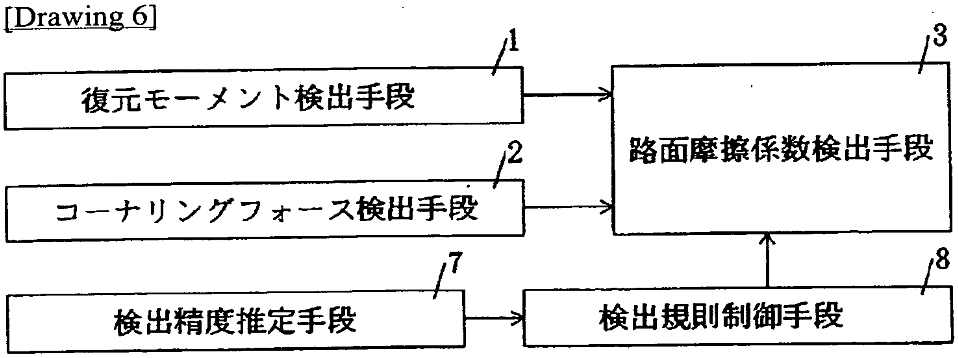
[Drawing 16]



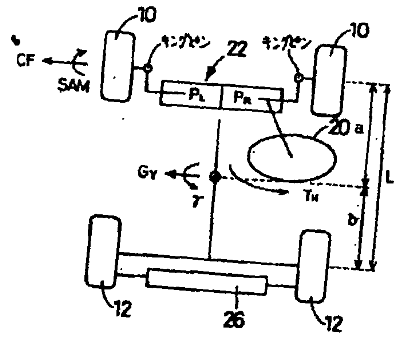
[Drawing 5]



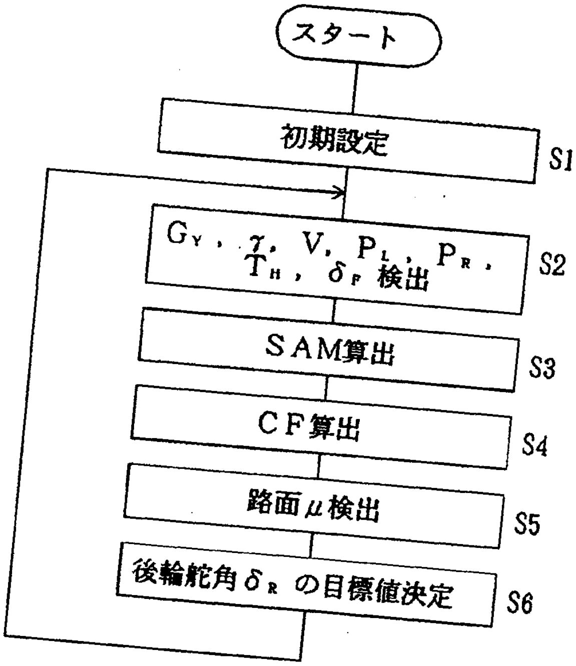
[Drawing 6]



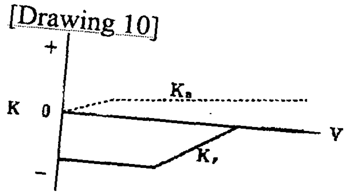
[Drawing 7]



[Drawing 9]



[Drawing 10]



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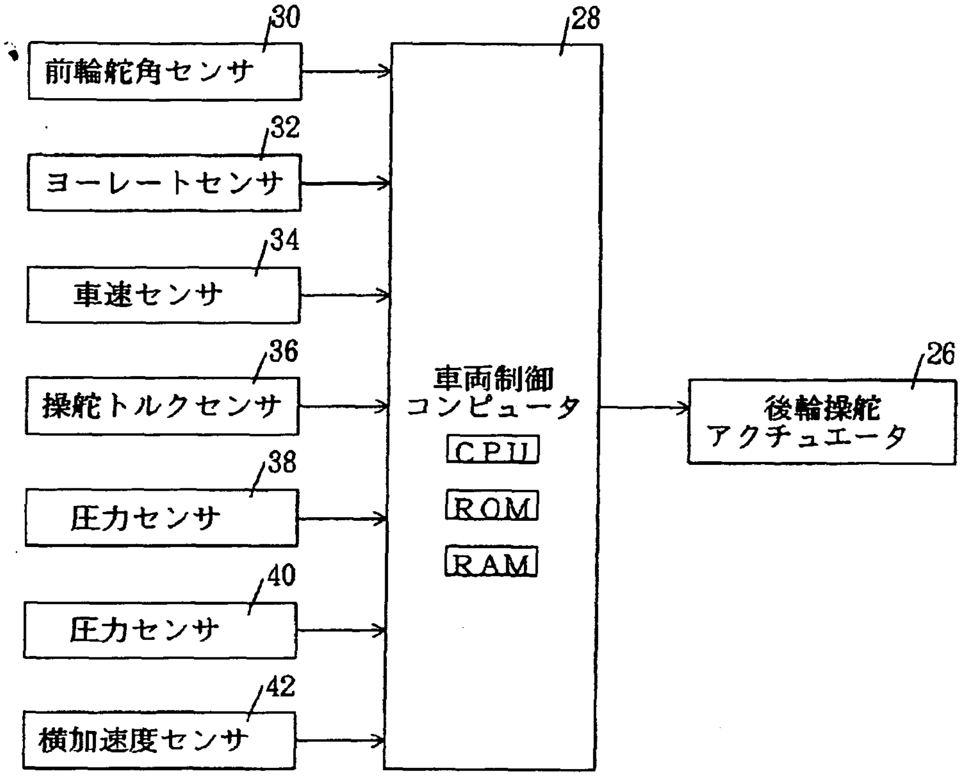
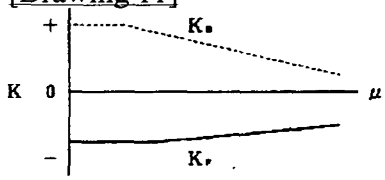
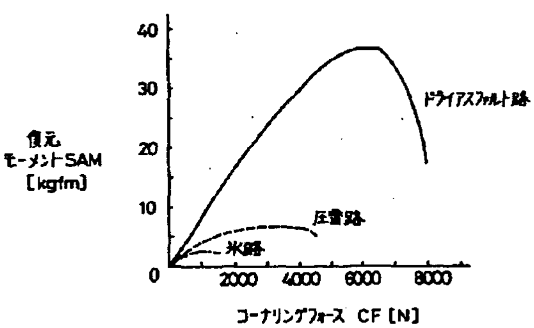


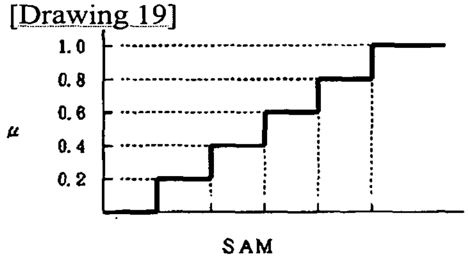
[Drawing 11]



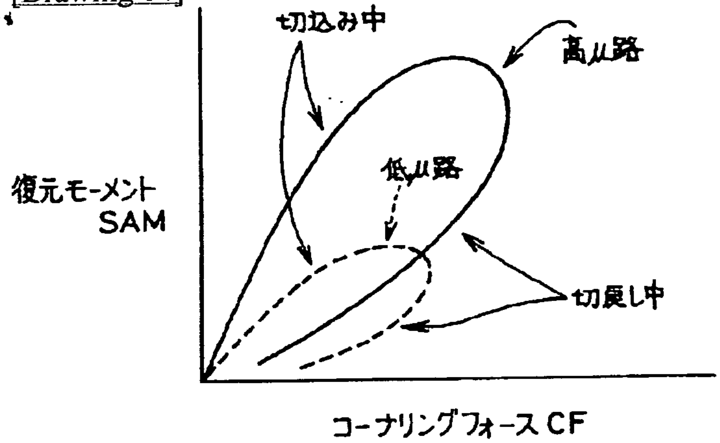
[Drawing 12]



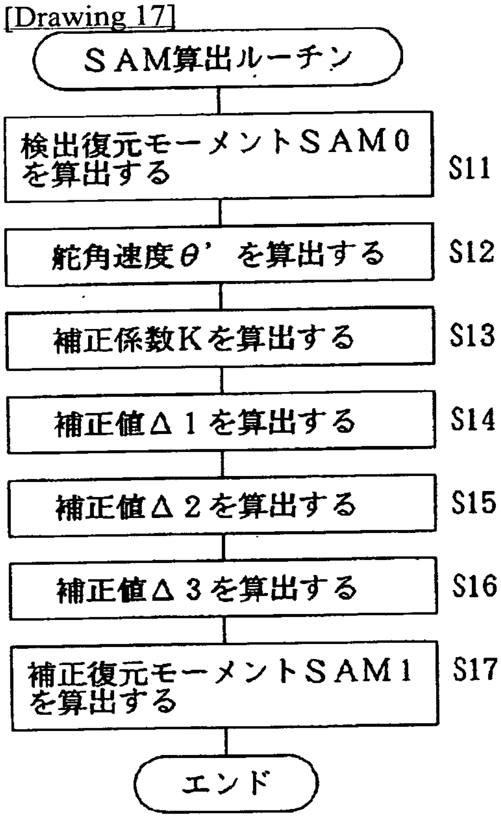
[Drawing 19]



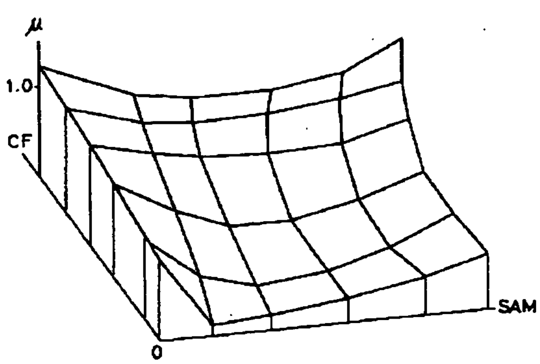
[Drawing 14]



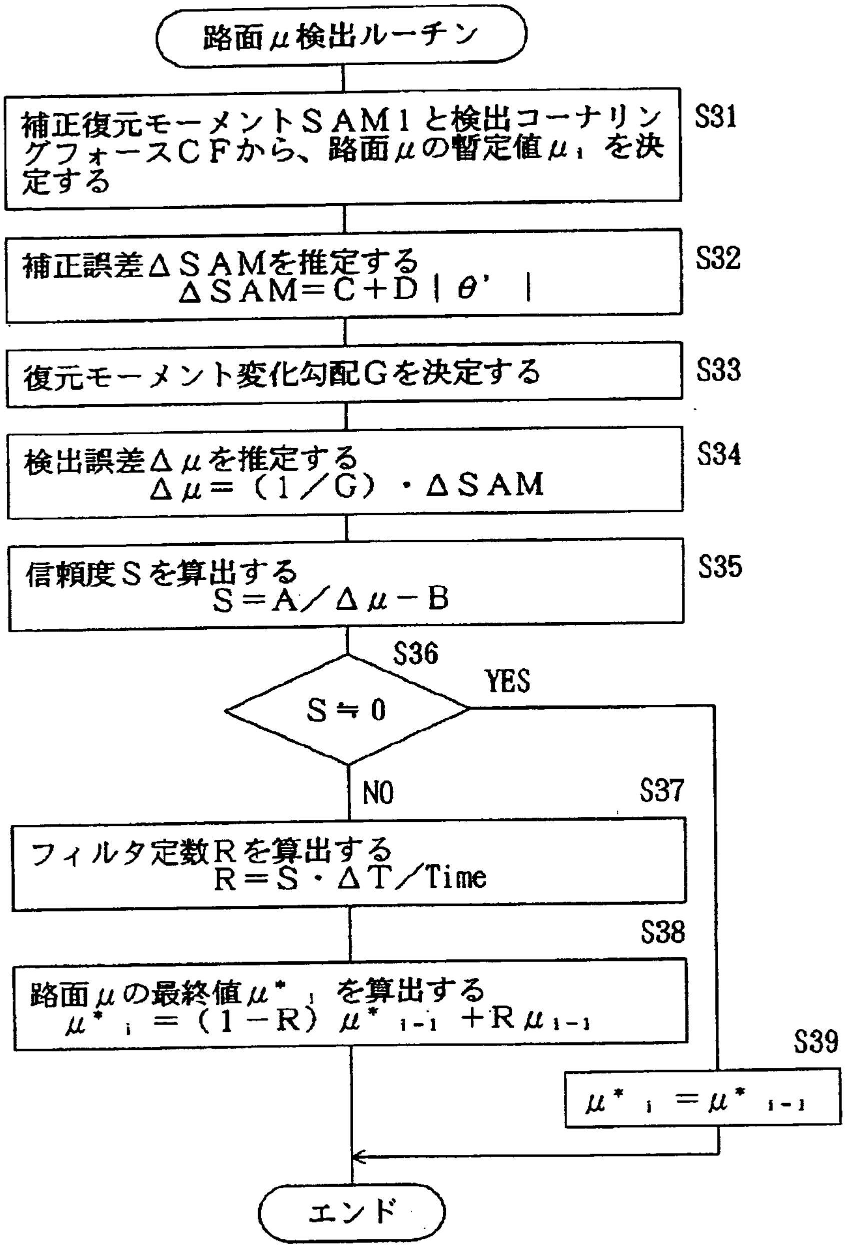
[Drawing 17]



[Drawing 20]



[Drawing 18]



[Translation done.]